



# Development of a Dedicated Ethanol Ultra-Low Emissions Vehicle (ULEV)

## Subcontractor

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## Objective

To develop a dedicated ethanol (EtOH) or EtOH-gasoline blend-fueled vehicle that meets California's ultra-low emissions vehicle (ULEV) standards. The vehicle must be competitive in cost and performance with a gasoline-fueled vehicle. The fuel cost need not be competitive.

## Approach

We are seeking to combine improvements in the engine and control systems with advanced treatment devices. Three improvements in engine design were planned and have been accomplished, as follows:



*Ford Taurus ethanol vehicle*

1. The compression ratio has been increased from 9.3 to 11.0 to take advantage of EtOH's high octane number (>100 research).
2. Air-assist injectors developed at Southwest Research Institute have been installed in place of the standard pintle injectors to improve the atomization of the fuel and reduce fuel transport delays.
3. An engine controller developed at Southwest Research Institute has been used to improve the control of fuel/air ratio and spark timing.

Four types of advanced aftertreatment devices are being investigated:

1. An electrically heated catalyst (EHC) plus a reformulated main catalyst.
2. A hydrocarbon (HC) trap upstream of an EHC plus main catalyst.
3. A combined HC trap and light-off catalyst followed by a main catalyst.
4. A system called the Rapid Exhaust Port Oxidation (REPO) system. With REPO, the catalyst is warmed





up very fast, and the unburned HC and CO are very low at the same time, thus contributing to very low tailpipe emissions during the cold-start phase.

## Accomplishments

Using the engine modified as described above, very clean (engine-out) starts have been demonstrated in the Federal Test Procedure (FTP) temperature range (20°–30°C), with no or very few misfires throughout the starting process. (Results of a misfire-free cold start are shown in the figure.) This is accomplished by providing a fuel enrichment and ignition timing schedule on an individual cylinder event basis that varies with the initial engine coolant temperature. Very strong starts have been demonstrated down to the limit of the refrigerated test cell, about -20°C.

Work has been completed on the development of model-based control. Algorithms developed include:

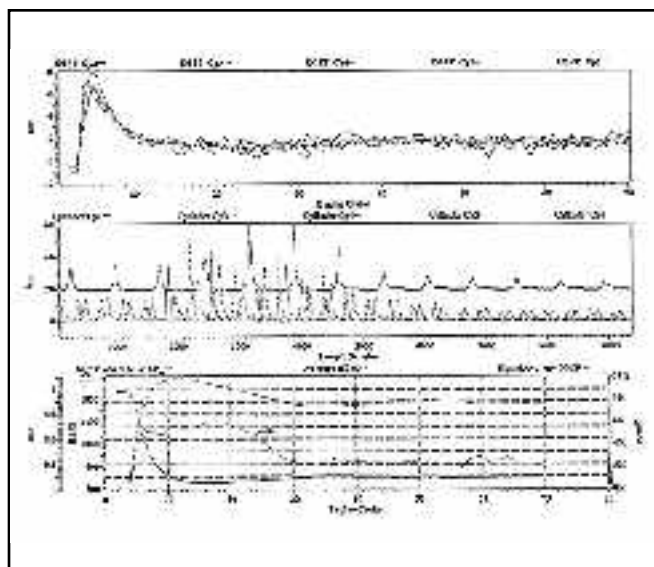
- Cylinder-event-based start-up
- Speed density with MAP observer (model-based) fuel control
- Adaptive learn for F/A control
- Transient volumetric efficiency (wall temperature)
- Fuel compensation by dual tau epsilon models
- EGR by electronic PWM valve with position feedback
- IAC deceleration control
- Spark timing control
- Idle control with IAC, with position feedback and dither
- EHC control
- REPO system secondary air requirements

The calibration of the engine on the test bed in the cold box has been completed, and the engine installed in the vehicle. The initial calibration of the engine in the vehicle has been completed, and the first full transient Federal Test Procedures (FTP) have been run. The best result from these preliminary FTPs is as follows:

	ULEV Standards*	Preliminary FTP**	
NMOG	0.04	0.028	g/mile
CO	1.7	0.726	g/mile
NO <sub>x</sub>	0.2	0.061	g/mile

\*at 50,000 miles.

\*\*green catalyst



## Future Direction

Work is continuing on calibration in the vehicle. It is anticipated that the main program goal that is to meet the California ULEV emission levels with this ethanol-fueled vehicle and an aged catalyst will be met by the time the current program ends in January 1997.

## Publications

Dodge, L. 1994. "Development of a Dedicated Ethanol Ultra-Low Emissions Vehicle (ULEV)." Presented at the Contractors Coordination Meeting, Detroit, MI. October.

Dodge, L. et al. 1995. "Development of a Dedicated Ethanol Ultra Low Emission Vehicle—System Design Report". Southwest Research Institute. NREL/TP-425-6722. February.

Dodge, L. et al. 1995. "Development of a Dedicated Ethanol ULEV—Phase II Report". SwRI. NREL/TP-425-8195. September.

Thring, R.H. et al. 1996. "Development of a Dedicated Ethanol ULEV Passenger Car". Presented at the Corn Utilization Conference, June 4–6, 1996, St. Louis, MO.

Thring, R.H. et al. 1996. "Development of a Dedicated Ethanol Ultra-Low Emission Vehicle (ULEV) —Phase III Report". Southwest Research Institute. NREL Draft. September.